

Skill Maintenance and Frequency Building:
Archival Data From Individuals With Autism Spectrum Disorders

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Individuals with autism spectrum disorders (ASDs) often exhibit well-documented difficulties maintaining skills after they learn them. Acquired skills often disappear from their repertoires. Frequency-building procedures used with other populations have been touted as having special potential relevance for this population, and one of the reported outcomes of training skills to high frequencies includes skill retention. Hence, using frequency-building procedures with individuals with autism may mitigate the retention problems observed in this population. This article presents a data set of skills trained to high frequencies in a clinical setting across a variety of learners with ASDs. Retention data are presented on skills at 1-, 2- or 3-, and 6-month postmastery points, and demonstrate a surprisingly high level of skill retention. The implications of these findings and essential next steps in research are reviewed.

DESCRIPTORS: precision teaching, fluency, autism, skill maintenance, learning outcomes

INTRODUCTION

Learning Characteristics of Persons With Autism

Individuals with an autism spectrum disorder (ASD) often exhibit a number of unique learning characteristics that require special adaptations for them to benefit fully from instruction. For example, many learners with an ASD display deficits in attending skills that make it challenging for them to gain new skills (APA, 2000). Such learners often lack good attending skills altogether, or their attention may be brief and fleeting (APA, 2000; Fabrizio & Moors, 2003; National Research Council, 2001; Weiss, 2005). For example, learners with autism may find it difficult to focus on the most relevant stimulus features of instructional materials, instead becoming distracted by irrelevant stimulus features and cues in the environment such as ambient noise (Lovaas, Koegel, & Schreibman, 1979; Scott, Clark,

& Brady, 2000).

Even when basic attending skills are intact, many people with ASDs continue to have difficulty sustaining their attention, attending to nuances, and learning by watching others. Individuals with ASDs generally do not acquire skills in informal ways, and they often require repetition and structure to learn new material. In addition, they

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often fail to generalize skills readily; their learning does not easily transfer across instructions, people, materials, or environments (Albin & Horner, 1988; Baer, 1999; Lovaas, Koegel, Simmons, & Long, 1973; MacDuff, Krantz, & McClannahan, 1993).

Finally, students with an ASD have difficulties in generalizing and maintaining skills and exhibit a tendency to lose skills (e.g., Durand & Carr, 1991; Openden, Whalen, Cernich, & Vaupel, 2009), making it necessary to review previously mastered material on a rich review schedule. This difficulty with skill retention also significantly affects the ability of the learner to progress hierarchically through curricular areas, as foundation skills may weaken or dissipate. Thus, instructional arrangements that help shape good attending skills and that support skill retention may prove maximally beneficial for persons with an ASD.

Beyond attention and skill retention, many individuals with an ASD often display performance problems as they engage in behaviors targeted for increase. In terms of skill demonstration, persons with an ASD often demonstrate problems in fluidity and speed of response. The performance of learners with ASDs can look slow and effortful, and they may exhibit long latencies to respond (Weiss, 2001, 2005). Such long latencies to respond and slow response speeds can have significant social and educational consequences, often resulting in missed social opportunities and difficulty keeping up with the pace of group instruction.

Behavior analysts working with individuals on the autism spectrum have recently considered the utility of frequency-building in educating such students (cf. Fabrizio & Moors, 2003; Kubina, Morrison, & Lee, 2002; Kubina & Wolfe, 2005; Weiss, 2001), with the ultimate goal of frequency-building procedures being the production of fluent skills for learners with an ASD. Training skills to high frequencies may serve as a remedy for the issue of retention of skills exhibited by individuals on the autism spectrum. While certainly a matter requiring further research, early data for children with an ASD suggest that skills trained to high frequencies are generally retained (Fabrizio & Moors, 2003). Unlike traditional intervention that requires a very heavy emphasis on retention programming, teaching skills to high frequencies may reduce the need for such explicit programming. This would provide a major advance in educational program

planning for children with autism because it would free up the instructional time allotted to the practice of already mastered skills.

Conceptual History of Fluency Outcomes

In the early 1980s, Eric Haughton and his compatriots began noticing what appeared to them to be an orderly relation between the frequency at which students could emit a given response or set of responses and the strength of that responding in terms of its ability to be retained, to endure, and to be available for combination with other responses (cf. Haughton, 1980). Haughton (1980) termed those orderly relations as outcomes of fluent performance, and he identified three outcomes specifically: skill retention, skill endurance, and skill application. In 1992, Johnson and Layng refined Haughton's (1980) definitions of the outcomes associated with fluent performance to include skill stability and skill adduction. Thus, today clinicians and researchers working in fluency-based intervention programs often discuss fluency as having five outcomes: skill retention, skill endurance, skill stability, skill application, and skill adduction.

While the definitions for each outcome of fluency have changed and continue to be refined, skill retention is generally thought of as maintaining performance quality and speed following some period without intervention (Fabrizio & Moors, 2003; Haughton, 1980; Johnson & Layng, 1992). Less agreement exists about the definition of skill stability and skill endurance, with some writers (e.g., Fabrizio & Moors, 2003; Johnson & Layng, 1992) defining skill stability as performance in the face of highly distracting conditions, while other pundits (e.g., Binder, 1996; Haughton, 1980) combine skill stability and skill endurance into one outcome that encompasses both performance in the face of distraction and performance across longer, untaught time intervals.

The Current Study and Its Goals

While much has been written about the retention benefits associated with training skills to high frequencies, a paucity of data exist supporting this assumption. The present study assessed the retention of skills taught to high frequencies (i.e., performance standards and frequency standards)

in an applied behavior analysis program for individuals with an ASD. The study sought to develop descriptive, objective, empirical information regarding the proportion of skills that passed retention check tests in this population of learners.

As such, the data reported here describe clinical outcomes rather than the results of a rigorous research project. Nevertheless, the results provide much-needed information on the important question and clinical assumption about the retention effects of training skills to high frequencies with learners with autism and related disabilities.

METHODS

Participants and Setting

Participants were 38 individuals ranging in age from 3 to 33 who attended programs at the Douglass Developmental Disabilities Center (DDDC), a behavior analytic program for individuals with ASDs. Students ages 3 to 21 attended DDDC's school program, enrolling in classrooms with instructor-to-student ratios ranging from 1:1 to 1:3. Adult participants ages 21 to 33 attended the Adult and Transitional Services Division of DDDC. Instructor-to-learner ratios in this setting ranged from 1:1 to 1:4, with a curricular focus on self-help skills, daily living skills, and vocational preparedness. Frequency-building occurred as a part of each participant's educational program.

In general, all of the participants carried a diagnosis placing them on the autism spectrum, and all were severely developmentally disabled and required fair amounts of support from adults. All of the participants had communication deficits. Some participants were vocal, but many vocal participants also augmented their communication with an alternative method (e.g., the Picture Exchange Communication System, speech-generating devices, sign language).

Skills Assessed

While the majority of skills taught sought to increase the frequency of the students' responding, some of the participants' intervention programs sought to change either the latency or the duration of their responding. Frequency served as the main dimension of interest for 154 of the skills reported here, collected across 38 learners ages 3 to 33. La-

tency served as the main dimension of interest for 59 skills, collected across 19 students ages 3 to 20. Duration served as the main dimension of interest for 20 skills, collected across 16 students ages 3 to 20. Sample goals for each of these dimensions of behavior appear in Table 1.

The frequency, duration, and latency aims reported in Table 1 were derived by sampling the performance of competent learners as they engaged in the same tasks.

General Frequency-Building Procedures

Because participants received individualized intervention, there was some variability in how skills were taught. However, several general procedures were in effect daily.

In the classrooms, frequency-building occurred within the structure of each participant's day. In general, daily timed practice occurred for all frequency-building goals. Prior to starting timed practice each day, the participants' teachers set a daily improvement goal for each participant based on the participant's charted performance data. Once the daily improvement goal was set, timed practice began. During daily frequency-building, participants completed a maximum of 10 timed practices per day on any given skill. However, if participants reached their daily improvement goal before they completed 10 timed practices, then timed practice ceased for the day and attainment of the daily improvement goal was rewarded (Fabrizio & Schirmer, 2002).

Throughout timed practice, the participants were included in their learning progress through procedures such as sharing their daily improvement goal with them, having the participants choose what they would like to receive if they reached their daily improvement goal, and showing them their charted performance as they completed successive timed practices when developmentally appropriate.

General Duration-Lowering Procedures

Duration-lowering procedures were also embedded into the structure of the participants' school days. In general, daily practice occurred for all duration-lowering goals. Prior to starting a practice, teachers reviewed the targeted duration with the student and set a goal of a slightly shorter duration for that day's practice session. As in procedures

Table 1: Examples of skills included in the assessment of retention. The first column describes the skill in general terms. The second column provides an example of the learning channels and movement cycles commonly used when targeting the general skill. The third column identifies the verbal operant often targeted when targeting the general skill, and the fourth column identifies the behavioral dimension manipulated when targeting the general skill. The final column lists the terminal performance level expected for each skill before intervention ended.

| General Skill Description | Learning Channel and Movement Cycle | Verbal Operant | Behavioral Dimension Targeted | Aim |
|----------------------------------|---|------------------------|--------------------------------------|--------------------------|
| Simple Motor Responses | Free-Squeeze | N/A | Frequency | 110-170 per minute |
| Reading | See word on a flashcard-Say word | Textual | Frequency | 35-60 per minute |
| Receptive Identification | Hear word-Touch picture | Nonverbal | Frequency | 26 per minute |
| Question Answering | Hear question-Say answer | Intraverbal (Sequelic) | Frequency | 15-30 answers per minute |
| Telling Time | See clock-Say time | Tact | Frequency | 7 per minute |
| Manners | Hear a request-Say "No, thank you." | Mand | Latency | Within 3 seconds |
| Requesting | See partially complete set of items-Say name of missing item | Mand | Latency | Within 3 seconds |
| Responding to Greetings | Hear a greeting phrase-Say an appropriate greeting phrase in return | Intraverbal (Sequelic) | Latency | Within 3 seconds |
| Dressing | Free-Do put on coat | Nonverbal | Duration | Within 15 seconds |
| Writing | See written question asking for personal information-Write answer | Intraverbal (Sequelic) | Duration | Within 2 minutes |

that sought to increase the frequency of students' responding, a maximum of 10 practice sessions occurred daily for each skill. If the student's performance reached the targeted duration before the

student completed 10 practices, no further practice sessions occurred that day, and the learner earned a reward for attaining the targeted (lower) duration. As in frequency-building, learners were included

in all aspects of the learning process.

General Latency-Lowering Procedures

As with the other dimensions of behavior targeted, practices for latency reduction programs were embedded into the school day. These were usually embedded into arranged instructional opportunities, and reinforcement was available for responses in the targeted time frame.

Retention Testing Procedures

Retention was assessed at 1-, 2-, 3-, and 6-month intervals. To assess retention, teachers arranged for students to complete timed practice again on skills on which the students had previously reached the designated frequency, duration, or latency aims. These retention check timings were identical to the original daily timed practices in terms of the materials used, the timing lengths, and the level of distraction present in the immediate environment. During the retention timings, teachers also informed the students of the goals they needed to reach, and used rewards if students attained their goals. Each retention check was run only once.

Dependent Measures

Number of individual skills that passed retention checks, number of individual skills that failed retention checks, and the percentage of each served as the dependent measures for this study. A skill passed a retention check if the participant's performance on the check met or exceeded his or her performance when daily timed practice ended after it had reached the aim for each given skill. A skill failed a retention check if the participant's performance on the check fell below his or her performance when daily timed practice ended after it had reached the aim for each given skill.

RESULTS

Data for the retention checks were taken from existing Standard Celeration Charts for current programs at DDDC. All programs are reported through 6-month retention checks, although some data are missing because of alterations or discontinuation in programming. Also, there was some variability in how classroom teachers designed a schedule for retention. In some cases, teachers elected to complete 2-month checks (rather than or

in addition to the more common 3-month check) following the 1-month check. These were clinical decisions made by teachers, based on their unique learning histories with each of the students with whom they worked. If a learner historically had difficulty maintaining skills, more frequent checks on retention were built into the individual's schedule. In all cases, retention phases did not contain timed practice on the skills assessed, and in this way all data are comparable.

Results of General Frequency-Building Procedures

A total of 149 programs that targeted higher frequencies of correct responding received 1-month retention checks. Of these programs, 147 passed the 1-month retention check, and 2 failed the 1-month retention check. Thus 98.7% of the skills taught to high frequencies passed their 1-month retention check. Eighty-seven of these programs received 2-month retention checks. Of the 87 skills, 86 passed their 2-month retention check, and 1 failed its 2-month retention check, yielding a 98.9% pass rate. Data for 3-month checks indicate that 75 of 78 checks were passed, yielding a 96.2% pass rate. One hundred eleven of 116 programs passed 6-month retention checks, yielding a 95.7% 6-month pass rate.

Results of General Latency Lowering procedures

A total of 59 skills taught to low latencies were assessed 1 month after the cessation of daily timed practice. All 59 of these skills passed their 1-month retention checks, yielding a pass rate of 100%. Two-month checks were done for 50 of these programs, and also yielded a 100% pass rate. Thirteen programs received 3-month retention checks, and yielded a 100% pass rate. Forty-five of 46 programs also passed 6-month retention checks, yielding a 6-month pass rate of 97.8%.

Results of General Latency Lowering Procedures

A small number of programs (18) were taught with duration as the targeted dimension of behavior. Thus, the sample of programs that sought to produce shorter durations is a considerably smaller sample of programs than those that sought to increase frequency or decrease latency. Eighteen programs were assessed 1 month following the end of daily timed practice, 10 at 2 months, 12 at 3 months, and 14 at 6 months. All pass rates

Table 2: Summary results for retention probes collected at 1-, 2-, 3-, and 6-month intervals for skills taught to high frequencies, skills taught to low latencies, and skills taught to low durations.

| | 1-Month Retention Checks | 2-Month Retention Checks | 3-Month Retention Checks | 6-Month Retention Checks |
|--|---|---|---|---|
| Skills taught to high frequencies | | | | |
| # Passed | 148 | 86 | 75 | 111 |
| # Failed | 2 | 1 | 3 | 5 |
| % Passed | 98.7 | 98.9 | 96.2 | 95.7 |
| % Failed | 1.3 | 1.1 | 3.8 | 4.3 |
| Skills taught to short latencies | | | | |
| # Passed | 59 | 50 | 13 | 45 |
| # Failed | 0 | 0 | 0 | 1 |
| % Passed | 100 | 100 | 100 | 97.8 |
| % Failed | 0 | 0 | 0 | 2.2 |
| Skills taught to short durations | | | | |
| # Passed | 19 | 10 | 12 | 15 |
| # Failed | 0 | 0 | 0 | 0 |
| % Passed | 100 | 100 | 100 | 100 |

for these retention checks were 100%.

While this represents a fairly complete data set, there are data missing. For this reason, fewer programs are reported for 6-month checks than for earlier checks. At times, programs were discontinued or modified in such a way as to make retention checks irrelevant to instruction. A skill may have been extensively modified or discontinued when educational staff realized that students' repertoires lacked component skills important to the targeted skill, or when a student's educational program mandated that instruction on the targeted skill end due to changes in educational priorities for the student. At other times, retention checks were

missed or data were absent from program records, yielding an incomplete chart. Below is a table that summarizes the missing data.

Skills were sometimes discontinued because a student changed educational placements. In such cases, it proved impossible to follow up after the student moved to other educational facilities. Modifications that were significant included alterations in the target skill across modalities of instruction (e.g., starting to work on a set of targeted responses on a Hear-Touch learning channel, and then changing that to a See-Match learning channel). Other reasons for missing data included lack of staff member adherence to collecting data on the

Table 3: Number of missing data entries for each behavioral dimension targeted as a function of the reason for each missing entry.

| | Incomplete | Discontinued | Modified | Other |
|------------------|------------|--------------|----------|-------|
| Frequency | 27 | 5 | 4 | 5 |
| Latency | 7 | 1 | 0 | 7 |
| Duration | 5 | 0 | 0 | 0 |
| Total | 39 | 6 | 4 | 12 |

retention check schedule as directed.

DISCUSSION

The data reported here represent the first published data set detailing the retention of skills taught to higher frequencies and lower latencies and durations for the population of learners with diagnoses on the autism spectrum. The data reported here appear to support the efficacy of interventions that seek to increase the frequency of responding in learners with autism. In particular the data support the assumption that adding such frequency-building procedures may enhance the skill maintenance enjoyed by persons with autism. As such, these data hold promise for future research and should encourage future study to determine experimentally the potential benefits of adding fluency-building procedures to clinical interventions used with persons with autism.

While these findings are potentially exciting, readers should interpret the data presented here with extreme caution. This was not an experimental study with control for alternative explanatory variables. As such, it is descriptive. Given the lack of evidence that exists for the application of frequency-building to learners with autism, descriptive studies serve an important function at this point in the development of such a research lineage.

While these results lend preliminary support to the utility of frequency-building procedures with this population of learners, they should encourage more rigorous explorations of the relevant questions.

Relevance of the Questions for Learners With Autism

Perhaps the most interesting aspect of the current data set relates to its social significance. Learners with autism frequently “lose” skills and are placed on maintenance schedules to retain skills even when these skills serve as components of larger, composite skills. From an efficiency perspective, if we could identify procedures that lead to greater skill maintenance, we could gain valuable instructional time. Given this potential improvement in the efficiency of instructional time use, the questions of why frequency-building appears to be associated with improved maintenance seem interesting from a clinical standpoint. It may be that the automaticity that results from timed practice makes those responses available as needed to the selecting environment (Johnson & Layng, 1992). Alternatively, it may be that overlearning (secondary to repeated practice) simply builds the strength of the responses. One of the research questions that remains unanswered relates to determining the

exact nature of the practice experience that creates fluent responding.

In either case, the attention to these time-based dimensions of behavior can truly enhance the clinical quality of a program. Moving beyond a percent correct mentality (whether or not frequency-building is used) helps to ensure that the availability and functionality of the responses are considered in the determination of mastery. Difficulties in the functional demonstration of skills clinically motivated us to examine rate-building as a way to build rate and availability of responses. For example, preschoolers transitioning to included settings had mastered percent correct criteria for returning greetings. However, in the novel classroom environments, latency to respond was often excessive, in some cases exceeding 7 seconds. Using latency as an additional criterion ensured that social opportunities with peers were not lost. Similarly, attending to duration for daily living tasks such as putting on one's coat or making one's bed ensured that negative social consequences were averted.

Skill Retention and Skill Maintenance

Skill retention and skill maintenance share key important features, including preservation of skill frequency and quality following some period without practice. Where the two differ, however, rests in the length of those no-practice periods. Generally speaking, measuring skill retention involves allowing greater periods to pass without the opportunity for the learner to emit the skill. For example, to test skill retention, researchers would need to take reasonable steps to ensure that the study participants did not have many—if any—chances to emit the targeted responses between the final session of frequency-building and the retention test itself. Such extraneous practice opportunities might affect the results obtained.

One of the best ways to ensure that practice opportunities do not present themselves outside of the experimental preparations being used involves researchers selecting arbitrary responses that the participants' typical environments are not likely to elicit. For example, researchers may elect to train responses involved with a second language that the study participants will never really learn

or use (cf. Wheetley, 2005) or labeling completely arbitrary visual stimuli (cf. McDonough, 2000).

While the use of such arbitrary stimulus-response associations presents several experimental advantages, the nature of applied behavior analytic research—as opposed to basic behavior analytic research—requires that researchers select responses that are ecologically valid and socially meaningful (Baer, Wolf, & Risley, 1968, 1987). Selecting ecologically valid and socially significant responses increases the likelihood that study participants will, in fact, find themselves in contexts that occasion the responses targeted through the research procedures that encompass the independent variable under study. All of the responses reported in this article were targeted for intervention precisely because of their high degree of ecological and social validity. Thus, while we ceased timed practice sessions, it is probable that skills were practiced once formal training ceased. Because the skills reported on in the current article had utility in the daily lives of the learners, practice opportunities likely occurred and reinforcement was likely contacted. In light of these considerations, it may be most appropriate to describe the outcomes reported here as maintenance effects. However, it remains impressive that the students maintained both the speed and the accuracy of the responses in the absence of timed and/or regular practice. Whether any functional, useful distinction exists between maintenance and retention is a matter for consideration by the broader community of behavior analytic researchers and practitioners interested in producing the most robust and positive outcomes for the learners with whom they work.

Limitations of the Current Study and Directions for Future Research

The primary weakness of the current study involves its lack of any comparison—either within individual participants as in a single-subject design, or across participants as in a group design—that would allow for control of extraneous sources of variance and alternative explanations of effects. A simple and important comparison group would be another data set examining the retention of skills taught without frequency-building, or latency or duration shortening. Such a comparison group of

skills might arise from behavior analytic intervention programs that do not systematically employ procedures designed to produce higher frequencies or lower latencies and durations of responding. It would be interesting to see how many retention checks are routinely passed by students in applied behavior analysis (ABA) programs that did not include such procedures. While most quality ABA programs collect such data routinely, these data are shared only rarely in a public forum such as a professional journal.

While a between-group comparison may prove interesting, the greatest information would come from a comparison that controlled for learners' exposure to extra practice and reinforcement instances with skills taught with similar levels of practice and reinforcement, but in the absence of procedures that systematically shape higher frequencies of responding, or shorter durations or latencies.

Given the lack of experimental control in the procedures reported here, it is unclear whether frequency-building (or latency and duration shortening) enhanced the achievement of retention as a fluency outcome (Doughty, Chase, & O'Shields, 2004). Improved retention may be a function of practice, which has been shown to facilitate learning (cf. Ericsson, Krampe, & Tesch-Romer, 1993; Samuels, 2002). Improved retention may also be a function of reinforcement, with the high levels of access to reinforcement in repeated timed practice procedures common in Precision Teaching possibly explaining the high levels of skill retention reported here. It may be that the outcome of improved retention is available without the full implementation of repeated timed practice protocols. Providing sufficient practice, focusing on overlearning, and maximizing access to reinforcement may result in equivalent outcomes without regard to the frequency, latency, or duration of responding. Those questions will remain unanswered until researchers complete parametric studies aimed at isolating the effects of each of the various procedures commonly employed in Precision Teaching-based skill-building programs.

Again, as noted, the results of this study should be interpreted with caution. While the data increase our interest in and enthusiasm for these procedures with learners with autism, they are tentative. Confirming data are required to make

inferences or statements about the specific impact of frequency-building procedures.

Importance of Current Findings

These data represent the first published data set examining the boundaries of retention as an outcome within a population of students with an ASD. It is imperative that data collected regarding the utility of this instructional approach are shared in published forums so that as a community of scientists and practitioners we accrue more objective information on the benefits of such procedures for these learners.

These data are encouraging, but not definitive. The potential impact of teaching skills to fluency appears to be significant, but more rigorous study is needed before such statements can be confidently made. While the current study suggests more questions regarding variables of primary importance, it appears to support the claim that skills taught to high frequencies associated with fluent responding are maintained well, even in a population of learners vulnerable to regression and skill loss. It is heartening to see descriptive data so consistent with the often reported clinical impressions and expressed assumptions that have characterized the use of these procedures with learners with an ASD. Such descriptive data are an important first step in the empirical examination of these procedures as applied to this population of learners.

These findings also call into question whether loss of skills is an immutable specific vulnerability of learners on the autism spectrum, or whether this vulnerability can be ameliorated effectively and efficiently by using highly effective teaching procedures. The potential utility of this approach is especially intriguing for this population of learners. It is our hope that research will more definitively answer these questions to help guide effective practice for practitioners working with learners with autism.

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